USING SIMULATION TO REDUCE OUT-PATIENT WAITING TIME: A CASE STUDY AT JITRA HEALTH CENTER

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Simulation is the act of reproducing the behavior of a system using a model that describes the operations of the system. Once the model has been developed, the analyst can manipulate certain variables to measure the effects of changes on the operating characteristics of interest. This project will presents a simulation model of the out-patient flow in Jitra Health Center during one week's observation. Focuses of this project are to determine the bottlenecks for outpatient at the center, and the effect of number of doctors and patient's arrival pattern on the waiting time.
Keywords: simulation, waiting time, what-if analysis

1.0 Introduction

The health care industry is under increased pressure from not only national political forces, but also from the competitive marketplace, to manage patient services more efficiently. The impact of restructuring the delivery of health care will cause significant changes in the entire health care system, resulting in a shift of overall hospital management philosophy. Traditionally, the objective of hospitals has been to stress high occupancy, growth in admissions and increased cases load. The most critical challenge for hospitals will be to provide quality health care in the most efficient and cost-effective manner possible. This includes getting the patient well and out of the hospital quickly. The viability of hospitals will depend on their success in responding to changing payer demands.

As a result of rapid growth of the economy and the availability of education for all in Malaysia, Malaysian have started to demand more efficient health care at a reasonable cost, and with better quality of service.

There are many indicators of quality assurance. In the out-patient department, the main indicator of quality assurance for patients is 'waiting' itself; patients should be attended to within an acceptable time (Huarng and Lee, 1996). Evans and Wakeford (1964), report that the main criticism of outpatient services in National Health Service (NHS) of UK was the lengthy waiting time. Waiting time is one consistent feature of dissatisfaction which has been expressed with the out-patient service (Mike Hart, 1996).

The using of simulation in healthcare industry is not a new story. Simulation allows significant exploration of multiple options, without spending enormous amounts of money on staff, training, equipment, and most importantly, without risking possible degrading in the level of healthcare (Barnes et. al, 1997). It has been utilized by many researchers to investigate various outpatient services. For example, Huarng and Lee (1996) use simulation model to reduce queue length and average waiting time, while Goitein (1990) use simulation to make medical scheduling.

This study presented the simulation model of the general outpatient flow at Outpatient Department (OPD) in Jitra Health Center. The total staff in OPD is 20, 3 doctors, 2 medical assistants, 2 staff nurses, 5 nurse aid, 2 pharmacist assistants, 6 staffs responsible at the registration counter. There are three sections in the OPD; registration, treatment and pharmacy.

The most serious problem at the department is overcrowding early in the morning. At the clinic's opening time (0800) there were about 50 people in the queue. The impact of this situation will decrease the efficiency and effectiveness of the OPD, where patient need to spend more time to receive the treatment.

This paper describes the simulation project of outpatient flow analysis and alternative approaches.

2.0 Data collected and analysis

The simulation software ARENA was used for this project. The OPD was considered as locations and patients were defined as entities. The flow of patients in the medical center is as followed. A patient first will take his arrival number, and then leave it with their IC at the registration counter. The staffs in the counter will search for the patient's treatment history document based on their IC number. During this process, the patient needs to wait until their name being called. Patients will make payment in the counter

before their IC, arrival number and the document returned to him. Patients holding an arrival number proceed to the waiting area to wait until it is their turn to see the doctor. After the treatment is over the patients will either go to the pharmacy for their medications or leave immediately if none is required. This research will consider the patients that take medication only because the numbers of patients who left the medical center without taking the medication or left before takes treatment are small.

Figure 1 shows the flow of outpatient in the center. Because it was difficult to record every patient's waiting time at each function (the registration, treatment and pharmacy), we collected only the arrival and exit time for simulation, and the waiting time at each function can be estimated from the results of the simulation. During a week study, 942 patients were included in this study. Beside the data on patient's arrival and exit time, the number of doctors for every 30 minutes was also collected (refer Table 3). The results of study were included in Table 1 and Table 2. From the results, it is understood that the consultation cannot catch up with the morning patient's concentration, and patient's stagnation occurred.

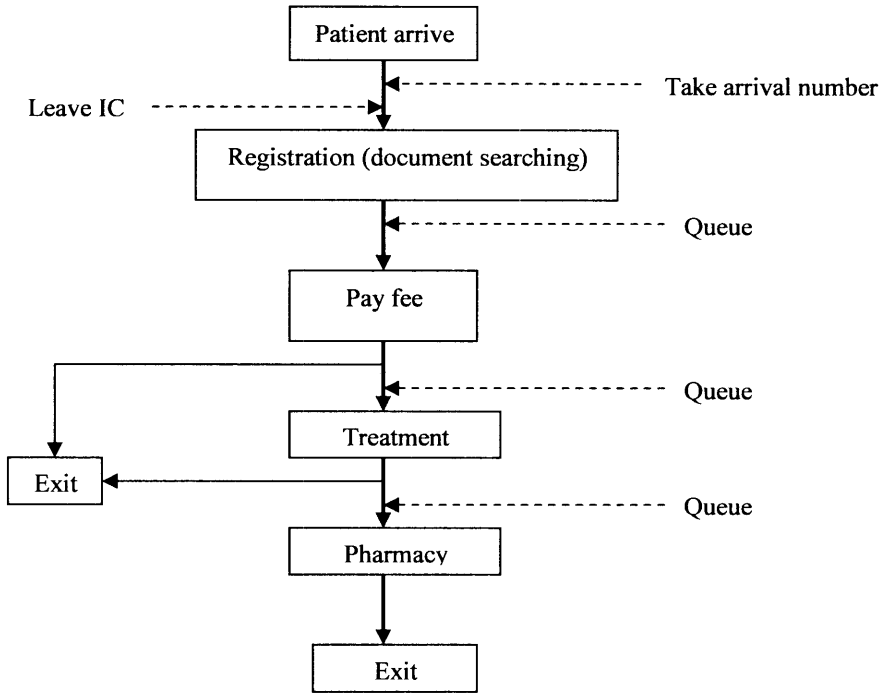

Figure 1: Outpatient flow

3.0 Model development

Base on observation; a health center simulation model was developed. However, it is difficult to create just one arrival because the patient's arrivals were different from time to time on the day. For example, the time between arrivals of patients is 1 minute in the morning (between 7 and 8 am). However, it will increase to more than 2 minute for the rest of the working hours. The analysis by Input Analyzer will express the time between arrival as -0.001 + LOGN(0.00268, 0.00218). However, when the program was run, the model result was slightly different from the real data. Thus, for this research, instead using just one arrival block, a number of arrival blocks will be used. The blocks will be based on one-hour time. By using these blocks, the number of patient's arrival can be controlled to be as same as in the real data.
Patient's time between arrivals in each block will be considered as constant and it value will be defined as mean of time between arrivals in the real data.
For the process, there will be three processes in the out patient department, registration, medical treatment and pharmacy. For this research, process time in registration and pharmacy will be considered as constant. The average process time in registration and pharmacy were identified as 1.5 and 2.0 minutes respectively.

	Sunday		Monday		Tuesday		Wednesday		Thursday		Saturday	
Time	Arrive	Exit	Arrive	Exit	Arrive	Exit	Arrive	Exit	Arrive	Exit	Arrive	Exit
0700	55	0	50	0	35	0	49	0	38	0	30	0
0800	44	15	41	15	37	19	44	18	20	21	33	14
0900	17	33	19	25	21	26	18	38	15	31	22	38
1000	18	35	1	39	12	20	12	35	12	17	15	28
1100	13	45	6	13	8	33	12	23	9	22	13	8
1200	4	23	0	25	3	18	4	25	4	7	10	29
1300	11	0	8	0	5	0	10	0			12	6
1400	31	14	18	15	17	16	21	15			20	11
1500	9	32	8	17	9	13	13	27			4	23
1600	1	6	1	3	0	2	0	2			0	2

Table 1: Results of study

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Saturday
0700	1:51	1:53	1:27	1:40	1:26	1:27
0800	2:26	2:31	2:05	2:02	1:30	1:22
0900	1:54	2:50	2:08	2:15	1:01	1:32
1000	1:19	1:52	1:21	1:33	0:45	1:49
1100	0:39	1:23	0:46	0:48	0:44	1:14
1200	0:11	0:00	0:11	0:16	0:10	0:30
1300	0:59	0:59	0:56	1:10		1:07
1400	0:53	0:35	0:37	0:38		0:53
1500	0:36	0:29	0:20	0:25		0:27
1600	0:09	0:10	0:00	0:00		0:00

Table 2: Average waiting time

	Sunday	Monday	Tuesday	Wednesday	Thursday	Saturday
0800-0830	0	2	2	3	3	2
0830-0900	1	2	2	3	3	2
0900-0930	3	2	2	3	2	2
0930-1000	3	2	1	3	2	2
1000-1030	3	2	2	2	2	2
1030-1100	3	2	1	2	2	2
1100-1130	3	1	1	2	1	2
1130-1200	3	1	2	3	2	2
1200-1230	3	2	2	2	2	1
1230-1300	1	1	1	1	2	2
1300-1400	0	0	0	0		0
1400-1430	1	2	2	3		1
1430-1500	3	2	2	3		2
1500-1530	1	1	2	2		2
1530-1600	2	1	1	2		2
1600-1630	1	1	1	0		2

Table 3: Number of doctors for every 30 minutes

The process times were determined by interviewed the staffs that responsible for the departments. Another process, medical treatment is more difficult. Processing time in this department is not constant, and it's varying according to the treatment that needed by the patients. To overcome the problem, treatment processing time were discussed with the doctors and the center unit administrators. According to the doctors, process' time to treat one patient is usually between 4 to 5 minutes. However most of the time, it is almost 5 minutes. By using this information, the most likely processing time is 4.9 minutes. The doctors were agreed with the figure. For the verification and validation of the model, the outpatient flow of the computer animation was discussed with the doctors and staffs of the OPD. The performance

measure, average total time in OPD, was compared with the real data. The comparison between real data and that for simulation model were shown in Table 4. In the light of these observations, it is concluded that the model performed adequately well.

	Sunday		Monday		Tuesday		Wednesday		Thursday		Saturday	
Time	Real	Simulation	Real	Simulation	Real	Simulation	Real	Simulation	Real	Simulation	Real	Simulation
700	1.85	1.83	1.87	1.74	1.45	1.48	1.67	1.53	1.43	1.46	1.42	1.34
800	2.43	2.18	2.52	2.42	2.07	1.98	2.03	1.96	1.5	1.44	1.38	1.38
900	1.9	1.84	2.87	2.88	2.08	2.05	2.25	2.16	1.02	1	1.53	1.53
1000	1.32	1.39	1.82	1.86	1.52	1.53	1.55	1.62	0.75	0.61	1.83	1.41
1100	0.65	0.77	1.45	1.45	0.85	1.03	0.8	1	0.73	0.59	1.25	0.96
1200	0.18	0.14	0	0	0.18	0.2	0.27	0.53	0.17	0.18	0.52	0.51
1300	0.98	1.02	0.87	0.85	0.88	0.71	1.17	0.96			1.05	1
1400	0.88	0.64	0.63	0.49	0.63	0.5	0.63	0.5			0.92	0.77
1500	0.6	0.43	0.5	0.49	0.33	0.32	0.42	0.39			0.5	0.16
1600	0.15	0.14	0.17	0.13	0	0	0	0			0	0

Table 4: Comparison average waiting time between real data and simulation data

4.0 Analysis

Base on the simulation model, the total patients' waiting time at the treatment block is account almost 82% of the total spending time at the OPD. From the results, it is clear that the patients waiting time is caused mainly by the queue to get doctor's treatment.

To identify the sources for the bottleneck, two factors that are believed lead to the bottleneck at the treatment block have been list. The factors were identified by have conversation with the staffs there and through observations. The factors are;

(i) number of doctors.
(ii) patients arrival pattern.

Analyze of data will be based on average waiting time.

4.1 Number of doctors

The average waiting time presented in Table 2 is taking into account the present of doctors. Thus, it is difficult to make comparison if the number of doctors is to be increased. To solve this problem, one new model will be developed. The model will assume that all the doctors were work according to the schedule (start working at 0800 and not taking any break during working hours, except from 1300 to 1400).

For the next what if analysis, model with an extra doctor, was developed. Analysis of the result shows the waiting time is decrease especially for morning session. However, after 1300, the waiting time is slightly affected (refer Table 5-comparison for Monday only). From the simulation result, in one sense, it seems that the hospital is lack of doctors. The increases on the number of doctor can reduce waiting time at the hospital. If one doctor is added to the system, it can reduce waiting time at hospital up to 30%.

However, the increases in the number of doctors are not appropriate because of the recruiting problem. Furthermore, the increasing in number of doctors, will lead to the decreasing in utilization rate of doctors (refer Table 5).

4.2 Patients arrival pattern

Table 6 reveals that, there is a pattern in patient arrival. Around 50% of the day's patients are arrived before 0900. The situation gets even worse as the registration counter opened at 0700 thus make waiting time increases one hour prior doctors arrival.

One simulation model was developed to analyze situation if the pattern of patients' arrival was changed. In the new arrival pattern, the number of patients who arrive before 0900 was reduced to 30% (15% at 0700 and 15% at 0800) from 50% on current situation. Result of the new model was showed in Table 7. The result shows that the average spending hour in the hospital was reduced drastically from 1.60 hours to 0.62 hours (or 37.2 minutes) or 61.25% decreases.

Arrival time	Average waiting time (hour)		
	Two doctors	Three doctors	Four doctors
0700	1.74	1.28	1.12
0800	2.34	1.44	0.98
0900	2.50	1.21	0.56
1000	1.51	0.14	0.14
1100	1.07	0.13	0.13
1200	0.00	0.00	0.00
1300	0.71	0.67	0.67
1400	0.31	0.18	0.18
1500	0.14	0.14	0.14
1600	0.13	0.13	0.13
Scheduled Utilization (%)	78.32	52.75	39.36

Table 5 Comparison of increasing number of doctor (result for Monday)

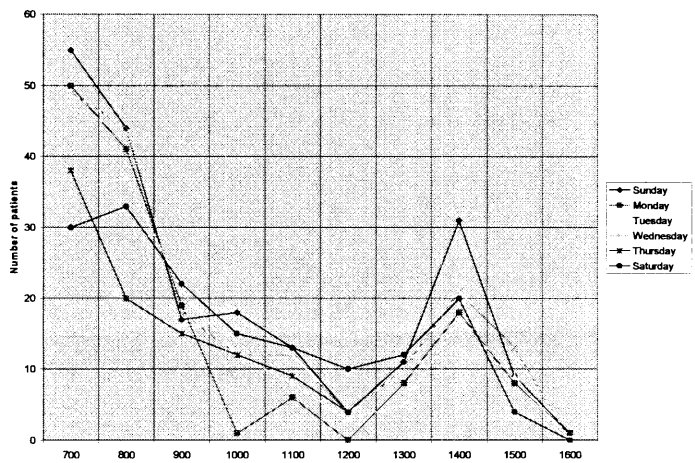

Table 6 Patient arrival pattern

5.0 Discussion

From the simulation models that have been analyze above, the main factor that leads to the length in spending time in hospital is lies in patients' arrival pattern. Thus, to reduce patients' spending time, efforts must be done to overcome this problem. To address this problem, there are two suggestions:

i) Doctors must reschedule their out-hospital activities

ii) Change the arrival pattern

5.1 Reschedule out-hospital activities

The first suggestion, the doctors must re-schedule back their out-hospital activities. If possible, their out-hospital activities must start after 1200. This will make three doctors available during morning session at the hospital, thus will decrease the patients' spending time. Table 8 shows the patients' spending time at hospital if the doctors reschedule their activities (three doctors for 0800 to 1200, then two at 1200 to 1630). The table considers Monday, Tuesday, Thursday and Saturday only, as on the other days, there are three doctors available.

Time of arrival	Average waiting time (hour)	
	Real arrival	New arrival
0700	1.74	1.11
0800	2.34	0.93
0900	2.50	0.79
1000	1.51	0.56
1100	1.07	0.34
1200	0	0.16
1300	0.71	0.71
1400	0.31	0.31
1500	0.14	0.14
1600	0.13	0.13

Table 7 Comparison of changing patient arrival pattern (result for Monday)

Arrival time	Average waiting time (hour)			
	Monday	Tuesday	Thursday	Saturday
0700	1.28	0.99	1.11	0.92
0800	1.44	1.01	0.83	0.78
0900	1.21	0.74	0.17	0.56
1000	0.14	0.14	0.13	0.16
1100	0.13	0.13	0.14	0.13
1200	0.00	0.14	0.16	0.14
1300	0.71	0.34		0.68
1400	0.31	0.34		0.53
1500	0.14	0.16		0.16
1600	0.13	0		0

Table 8 Result after the doctors rescheduling their out-hospital activities

5.2 Change the arrival pattern

The second suggestion, probably the most effective method to reduce spending time, is by changing the current arrival pattern. As stated before, number of patients who come before 0900 is almost 50%. Table 9 shows the maximum number of patients that was suggested for three situations; when two doctors were available, when three doctors was available and when three and two doctors were available. Each doctor was scheduled to take 30 minutes recess respectively during morning session. By implement this method, patients' spending time at the health center can be reduced significantly to around 8 minutes. Moreover, the utilization for each staff has increased.

6.0 Conclusion

This research have identified main problem that caused long spending time at Jitra Health Center thus created congested situation at the place. The problem is due to the unbalanced between the numbers of patients' arrival with the number of doctors that were available especially during morning session. Effort to increase the number of the doctors at the health center found unsuitable, as the doctors' utilization will decrease. Furthermore, it is impossible to increase the number of doctors as other hospital in nationwide now facing doctors' shortage. To overcome the problem, it is suggested that the doctors at the health center must re-schedule their out-hospital activities to ensure that three doctors will available during morning session, thus decrease patients' spending time. However, the most impressive solution to this problem is, by introducing a system that can estimate patient treatment time.

	2 doctors	3 doctors	3 & 2 doctors
0800	12	24	24
0900	24	30	30
1000	24	36	36
1100	24	36	36
1200	22	33	33
1300	0	0	0
1400	24	36	24
1500	24	36	24
1600	10	15	10

Table 9 Maximum number of patients per session

7.0 References

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